Chapter 3

INTERPRETATION OF INVENTORY DATA

3.1 FOREST GROWTH

3.1.1 Growth projection

The method used to project m^3 accretion involves stand tables that are expressed in terms of average basal area per hectare of growing stock rather than in number of stems or gross volumes. This is based on the assumption that a m^2 of basal area in trees of each diameter class will continue to experience an annual growth as experienced by the same size and type of trees during the preceeding period of measurement. Therefore, in Table 8, growing stock level, trees harvested, mortality, accretion, and ingrowth are all in terms of basal area.

Tables 8 and 9 on the following page illustrate growth parameters measured in the last ten years, and on this basis, projected with adjustments for mortality, harvest, and ingrowth.

3.1.2 Growth prediction

Considering that all sawtimber size trees (25 cm dbh class and larger) in the commercial forest stratum will be harvested during an adjustment period of 80 years, there is a total gross volume of 711 769 m^3 or 366.33 m^3 per hectare.

Allowing a deduction for mortality, projected net annual accretion in sawtimber trees only is .349 m^3 per hectare. Therefore, the total of the half period projected net accretion during the 80 years in which the trees will be harvested is:

$$\frac{.349 \text{ X } 80}{2} \text{ X } 1\ 943 = 27\ 124 \text{ m}^3$$

3.1.2.1 PROJECTED NET GROWTH WITH ADJUSTMENT FOR MORTALITY, HARVEST, AND INGROWTH FOR POLETIMBER AND SAWTIMBER

Table 8

COMMERCIAL FOREST STRATUM

SPECIES	1978 AVERAGE m^2 OF BA/ha	10 YEARS MORTALITY m^2 OF BA/ha	10 YEARS TIMBER CUT m^2/ha	SURVIVOR TREES TO 1988 m^2/ha	ANNUAL ACCRETION m^3/m^2	PROJECTED ACCRETION m^3 per ha		ANNUAL INGROWTH m^3/ha	ANNUAL NET GROWTH m^3/ha
						ON SURVIVOR TREES	½ PERIOD ON HARVEST TREES		
Cedrus deodara	.769	.054	.025	.689	1.449	.130	.0022	.016	.143
Pinus wallichiana	.586	.003	.013	.570	1.871	.118	.0016	.007	.127
Abies spectabilis & Taxus baccata	1.488	.082	-	1.479	1.438	.285	-	.058	.343
Picea smithiana	.323	.009	.001	.313	1.275	.078	.0001	.007	.085
TOTAL	3.165	.148	.040	3.051	6.033	.611	.0039	.088	.703

Table 9

DENUDED FOREST STRATUM

Cedrus deodara	.411	-	-	.411	1.523	.261	-	.014	.275

The total available gross volume over the rotation period which can be harvested will be:

Total gross volume of all sawtimber trees	– 711 769 m^3
Total half period net accretion for the sawtimber	– 27 124 m^3
Total gross volume available	= 738 893 m^3

The average annual cut during the 80-year period that the area could sustain would be 9 236 m^3 (738 893 $\div$ 80). At the end of the year 2058, or the end of the adjustment period, any additional volume that could be harvested from the commercial stratum will have to be sustained on trees that grew into the sawtimber size class (ingrowth).

To estimate this, it is necessary to predict: (1) the volume of such trees in the year 2058, and (2) the average annual growth per hectare that will then be realized.

The following predictions must be considered:

1. The number of ingrowth trees from pole to sawtimber for each 10-year period will continue to be the same as during the period of projection. From an analysis of the inventory data, this ingrowth has been determined to be 7.88 stems per ha for pole material.

2. That during each of the subsequent 10-year periods following ingrowth, there will be a mortality rate of 1.15 percent.

3. The average annual growth in diameter of ingrowth trees during each of the successive 10-year periods to the year 2058 will be the same as the average growth measured in the young and immature diameter classes.

4. The desirable stocking goal at the end of the adjustment period should be approximately 150 m^3 per hectare.

Table 10

Calculation of periodic increases in volume that can be expected during the next 80-years on only those trees that grow into sawtimber during the period from 1979 to 1988, inclusive.

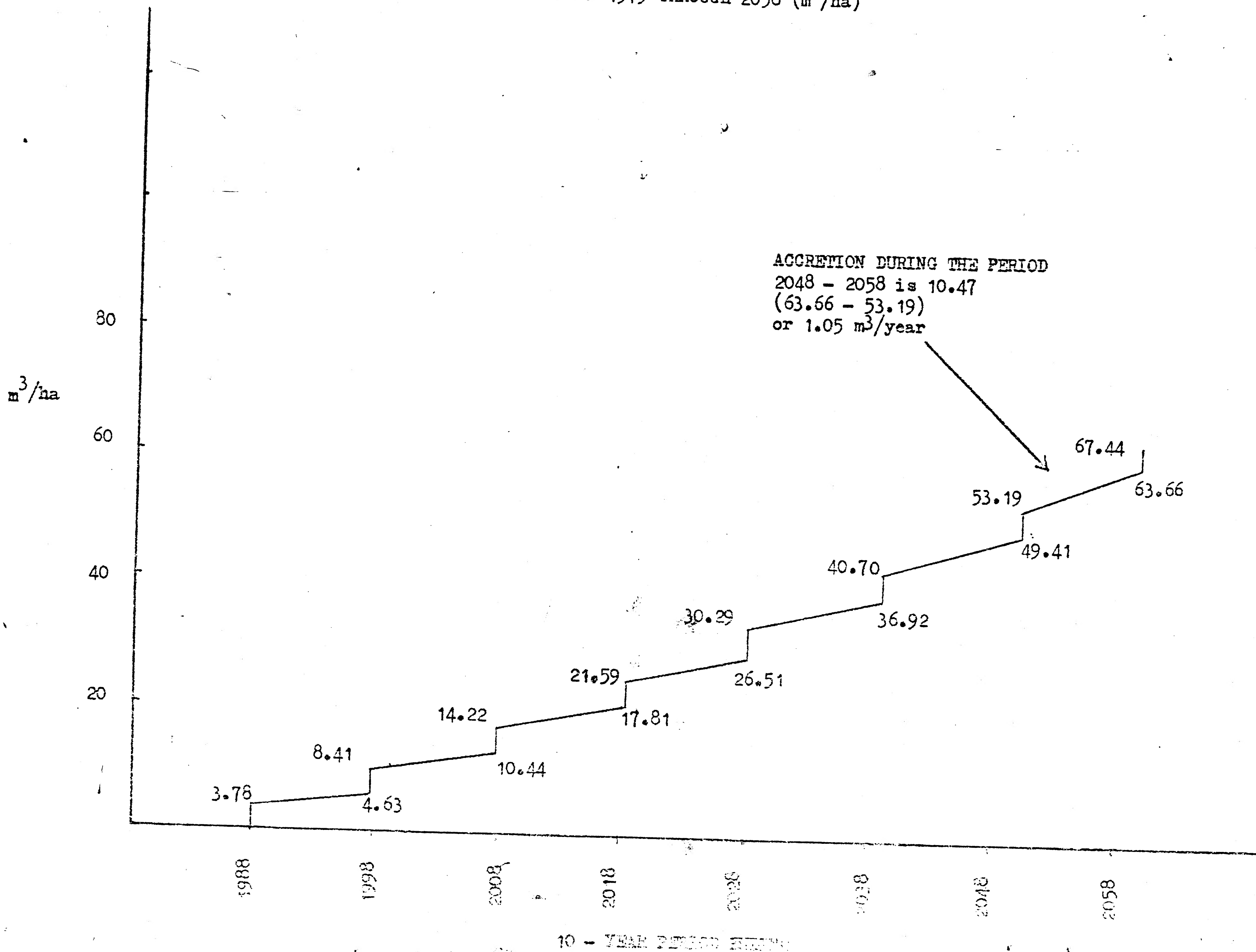
10-year period ending	Estimated No. of Trees/ha surviving to end of period 1/	Avg. dbh of survivor trees 2/ (m)	Avg. volume per tree 3/ (m3)	Avg. total volume per hectare end of period (m3)
1988	7.880	.282	.480	3.782
1998	7.789	.314	.594	4.627
2008	7.700	.346	.755	5.814
2018	7.611	.378	.969	7.375
2028	7.524	.410	1.156	8.698
2038	7.438	.442	1.400	10.413
2048	7.353	.474	1.698	12.485
2058	7.268	.506	1.960	14.245

1/ Based on loss of 1.15 percent during each 10-year period.

2/ Based on same average growth in dbh for the respective diameter classes as measured in the young and immature trees

3/ From local volume equations.

Figure 1. CUMULATIVE INGROWTH VOLUME OF SAWTIMBER DURING 80-YEAR PERIOD FROM 1979 THROUGH 2058 (m^3/ha)



On this basis, the periodic increases in total gross volume have been calculated in Table 10. The calculations show that in the year 2058, the estimated 7.27 trees per ha that have survived will have a total volume of 14.25 m^3 per hectare.

The cumulative effect of all volume increments is shown in Figure 1. The combined effect of ingrowth and subsequent accretion on the ingrowth stems, during the 80-year period illustrated by Figure 1 will provide an average volume of 67.44 m^3 per ha or 130 958 m^3 for the entire stratum.

The optimum stocking goal desired was set at 150 m^3 per ha. Under the following growth prediction, there will be only 67.4 m^3 per ha at the end of rotation period. To eventually achieve 150 m^3 per ha, would require volume from regeneration and saplings that would grow to sawtimber size during the adjustment period of 80 years.

On the basis of this prediction, it would not be feasible to assume that the 7.88 trees per hectare left after removal of sawtimber trees would contribute the total of predicted volume resulting from pole ingrowth. Damage caused by logging as well as potential windblow of the scattered poles would reduce the ingrowth volume. It may be more beneficial to harvest all poles and expect regeneration to supply the necessary volume at the end of the rotation period.

3.2 STATISTICAL ANALYSIS

The statistical analysis of sampling unit data was based on sampling unit volume for each stratum and species group. Values for the analysis were computed on a per hectare basis indicating sampling precision and uniformity.

3.2.1 Combined sampling error

Sampling precisión in terms of a combined sampling error at a 67 percent confidence limit for the volume data for all species in the commercial and denuded strata is $\pm$ 5.3 percent.

3.2.2 Commercial Forest Stratum

The standard error in the commercial stratum for pole timber in the all species group is ± .66 m^3 per hectare or 1 282 m^3 for the entire stratum. This implies that the true but unknown value based on sampling is within a range that is plus or minus 1 282 m^3 of the total volume. For sawtimber in the all species catagory, the sample contains a standard error of ± 20.5 m^3 per hectare or 39 831.5 m^3 for the entire commercial forest.

Combining pole and saw timber in the commercial stratum results in a sampling error of ± 5.5 percent and a standard error of 20.0 m^3 per hectare, or 38 860.0 m^3 for the entire stratum.

3.2.3 Denuded Forest Stratum

In the denuded forest stratum, for pole material, the sampling error is ± 37.9 percent and the standard error is ± .21 m^3 per hectare. Saw timber in the same stratum has a sampling error of ± 25.2 percent and a standard error of ± 11.5 m^3 per hectare. Combining both pole and saw material results in a sampling error of ± 25.1 percent and a standard error of ± 11.6 m^3 per hectare or 7 853.2 m^3 for the entire stratum.

3.2.4 Both strata combined

In the all forest strata, the standard error of the estimate for pole material, all species is ± 11.0 percent, and for sawtimber, all species, is ± 5.5 percent. The value for the combined poles and saw is ± 5.3 percent. These sampling errors are considered adequate for saw timber and moderately high for pole material in the all species, combined strata.

3.2.5 Summary tables

Tables 11-13 provide summaries of values from the statistical analysis discussed, above.

3.3.5.1 Statistical values for species group and size

Table 11

COMMERCIAL FOREST STRATUM

	POLES			SAWTIMBER			COMBINED
STATISTICAL VALUE	CEDAR	COMBINED SPECIES	ALL SPECIES	CEDAR	COMBINED SPECIES	ALL SPECIES	POLES & SAW ALL SPECIES
STANDARD DEVIATION	± 3.52 m^3/ha	± 8.43 m^3/ha	± 9.0 m^3/ha	± 290.2 m^3/ha	± 181.3 m^3/ha	± 277.5 m^3/ha	± 271.4 m^3/ha
STANDARD ERROR OF MEAN	± .26 m^3/ha	± .62 m^3/ha	± .66 m^3/ha	± 21.4 m^3/ha	± 13.4 m^3/ha	± 20.5 m^3/ha	± 20.0 m^3/ha
COEFFICIENT VARIATION	± 254.9 %	± 204.3 %	± 166.6 %	± 135.1 %	± 126.7 %	± 77.9 %	± 75.0 %
SAMPLING ERROR	± 18.8 %	± 15.1 %	± 12.3 %	± 10.0 %	± 9.3 %	± 5.7 %	± 5.5 %

Table 12

DENUDED FOREST STRATUM

STATISTICAL VALUE	POLES-CEDAR	SAWTIMBER CEDAR	COMBINED POLES & SAW CEDAR
STANDARD DEVIATION	± 1.78 m^3/ha	± 96.7 m^3/ha	± 97.7 m^3/ha
STANDARD ERROR OF MEAN	± .21 m^3/ha	± 11.48m^3/ha	± 11.6 m^3/ha
COEFFICIENT VARIATION	± 319.0 %	± 212.5 %	± 211.9 %
SAMPLING ERROR	± 37.9 %	± 25.2 %	± 25.1 %

Table 13

ALL FOREST STRATA

STATISTICAL VALUE	POLES ALL SPECIES	SAW TIMBER ALL SPECIES	COMBINED POLES & SAW
STANDARD ERROR OF ESTIMATE	11.04 %	5.5 %	5.3 %

Chapter 4

EROSION DAMAGE ASSESSMENT

4.1 EROSION SURVEY

In conjunction with a forest inventory conducted in the Diwagal watershed in the summer of 1978, a survey was undertaken to assess natural and accelerated soil erosion. The inventory included delineation of various types of soil erosion and related site data showing the dominant conditions of slope, soil, and present vegetation cover. The soil erosion survey information will be useful for effective guidance of programs for erosion control, watershed conservation, and land use management.

4.1.1 Location of survey

The survey area was limited to the coniferous portion of the Diwagal watershed. Three major strata were differentiated according to past and present land use, commercially operable areas, and non-commercial land. Sampling was conducted uniformly throughout the entire watershed and special emphasis was placed on a denuded forest stratum. This denuded area resulted from a forest fire about 20 years ago and is now being used by local inhabitants for shifting cultivation.

4.1.2 Methods in brief

Along sampling unit lines, oriented east-west at intervals of 500 meters apart throughout 5 244 hectares in the Diwagal watershed, visible soil erosion occuring 50 meters to the north and 50 meters to the south was recorded. Erosion types and severity were noted to aid in planning installations and revegetation required to control further erosion. A map was prepared outlining the major sites where various types of erosion occured within the sampling boundary.

Chapter 1

1. INTRODUCTION

1.1 GENERAL

The Democratic Republic of Afghanistan, assisted by the United Nations Development Programme and the Food and Agriculture Organization of the United Nations, began an inventory of the Diwagal Forest in August 1978. The purpose of the inventory was to collect data required to prepare management and logging plans for a forest designated as a demonstration area. The inventory's field operation was completed at the end of September 1978 and data compilation was done during the winter of 1978-79. This plan was compiled and written during the spring of 1979.

1.2 DESCRIPTION OF THE DIWAGAL FOREST AREA

1.2.1 Location

The Diwagal forest is situated in the southern part of the Kunar drainage system. It is flanked in the east by a ridge separating the Diwagal and Badel watersheds. In the west, a major ridge separates the Nurgal and Diwagal watersheds and in the north, a ridge separates the Diwagal, the Korangal, and the Chapadara watersheds. The portion of the forest surveyed included its coniferous stands that are limited to the northern and western portions of the watershed. The remaining areas described as forest in the watershed consist of scrub oak and wild olive stands.

1.2.2 Topography

The topography varies considerably throughout the watershed. In the central part, it is undulating and occasionally rolling. To the south and west, distinct rocky outcrops and steep gradients are frequently seen. A large portion of the watershed features a south-east and south-west exposure. The highest point in the Diwagal forest is 3 460 m in the north and the lowest is 800 m in the south-west.

4.1.3 Classification of erosion types

Erosion in the Diwagal watershed resulted mainly from accelerated, man-induced causes. Three types of water related soil erosion considered for the survey are outlined as follows:

(a) Sheet erosion is the constant and gradual removal of soil by rainfall in thin sheets over a considerable area. It is considered moderate when 25-75 percent of the topsoil has been removed and severe when all the topsoil and 50 percent of the subsoil has been displaced.

(b) Rill erosion are small but well defined incisions on the soil surface caused by the cutting action of water. Several small channels are formed and often lead to gullying.

(c) Gully erosion results largely because of the erosive force of concentrated runoff water in unstable depressions or in rills. They are characterized by 'V' shaped channels and tend to widen and deepen as the velocity of the accumulated water increases. They are often classified as either shallow or deep gullies.

4.2 MAJOR PHYSICAL FACTORS AFFECTING SOIL EROSION

4.2.1 Precipitation

The spatial distribution, amount, and timing of rainfall is a major factor in the amount of runoff available for streamflow. In the Diwagal forest, rainfall occurs in sporadic bursts and has an important effect in dislodging soil particles where vegetation cover is sparse, thereby increasing the erosion potential.

4.2.2 Vegetation

Vegetation intercepts rainfall and reduces the harmful effect of rain splash. A forest cover ideally intercepts rainfall and slowly redistributes it through stemflow to the soil surface. In the denuded forest areas,

shrubs are the major intercepting vegetation type and, therefore, the erosive impact caused by rain splash is much greater. The type and amount of supporting vegetation either intercepting rainfall, producing litter, or stabilizing soil by an extensive rooting system is an important factor in preventing soil erosion.

4.2.3 Infiltration rate

Soils that have a low infiltration potential such as clay textures found in the Diwagal forest are more prone to erosion. Greater runoff volumes accumulate on soils with low moisture holding capacities. The inherent erodibility of soils combined with short and heavy rainfalls in areas having a scant vegetation cover will result in major erosion problems.

4.2.4 Topography

The length and steepness of slopes have a direct bearing on water velocity. Many steep gradients are found in the Diwagal watershed and, therefore, these areas that have eroded sites need improvement structures to hinder the cutting and carrying power of surface runoff. Slope aspect in terms of vegetation cover and the rate of snow-melt is also a factor in total water available for runoff.

4.3 EROSION DATA COLLECTED

The following tables summarize erosion data compiled from the erosion survey.

Table 14

TYPE OF EROSION, FREQUENCY OF OCCURANCE, AND TOTAL AREA BY STRATA

Erosion Type	Denuded Forest		Commercial Forest		Non-Commercial Forest	
	Frequency of Occurance	Total Area (ha)	Frequency of Occurance	Total Area (ha)	Frequency of Occurance	Total Area (ha)
Sheet	7	1.035	4	.328	8	.483
Rill	19	3.693	3	.123	4	.187
Gully	17	1.036	2	.012	3	.128
Total	43	5.764	9	.463	15	.798

Table 15

AVERAGE AREA PER STRATUM PER EROSION TYPE SURVEYED

Erosion Type	AVERAGE AREA (ha) PER SITE		
	Denuded Forest	Commercial Forest	Non-Commercial Forest
Sheet	.148	.082	.060
Rill	.194	.041	.047
Gully	.061	.006	.043

Table 16

PROJECTED TOTAL EROSION AREA PER STRATA

Stratum	Total Area Sampled (ha)	Percent of Total Stratum Sampled	Projected Total Eroded Area (ha)
Denuded Forest	141.14	20.8	27.74
Commercial Forest	381.84	19.6	2.36
Non-Commercial Forest	439.22	17.6	4.53
Total	962.20		34.63

Table 17

PROJECTED TOTAL EROSION AREA PER TYPE AND STRATA

Erosion Type	TOTAL ESTIMATED EROSION (ha)		
	Denuded Forest	Commercial Forest	Non-Commercial Forest
Sheet	4.98	1.67	2.74
Rill	17.78	.63	1.06
Gully	4.98	.06	.73
Total	27.74	2.36	4.53

Table 18

GULLY CHARACTERISTICS BY STRATUM

Stratum	Average Length (m)	Average Depth (m)	Average Width (m)
Denuded Forest	27.0	.9	4.5
Commercial Forest	8.0	1.0	2.0
Non-Commercial Forest	20.0	.8	2.0

Table 19

PERCENT SLOPE ON ERODED SITES PER STRATUM

Stratum	(GULLY)			(RILL)			(SHEET)		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Denuded Forest	24	68	49	18	90	18	39	70	60
Commercial Forest	64	64	64	-	Nil	-	-	Nil	-
Non-Commercial Forest	50	70	56	8	90	50	8	90	59

Table 20

PERCENT VEGETATION COVER ON ERODED SITES BY STRATA

Vegetation Type	Denuded Forest	Commercial Forest	Non-Commercial Forest
Grass	3.0	13.0	4.0
Shrub	33.0	10.0	29.0
Tree	2.0	6.5	11.0

4.4 ANALYSIS

4.4.1 Erosion distribution

In the Diwagal watershed, a total of 962 ha were sampled for erosion in various strata. Gully, rill, and sheet erosion were tallied on 67 separate sites and of these, 64 percent were located in the denuded forest stratum.

The total sampling area in the denuded stratum was 141 ha or 20.8 percent of the total stratum. On a projected basis, 28 ha must be rehabilitated. The eroded sites represent 4 percent of the total stratum. Rill erosion is predominant covering 18 ha.

In the commercial forest stratum, 19.6 percent of the total was sampled and resulted in a projection of 2.4 ha of eroded land.

The non-commercial forest stratum featured 4.5 ha of eroded land based on 17.6 percent sampling of the total stratum area.

4.4.2 Vegetation

The lack of vegetation to intercept rainfall during intense storms has resulted in the formation of moderate rill and gully erosion. Average shrub cover in the denuded area was 33 percent with a forest canopy of only 2 percent.

In areas where slope is steep and dryland cultivation is occuring, unless soil is stabilized with permanent vegetation eventual loss of the remaining topsoil will occur. The trend of shifting cultivation spreading to commercial areas will further aggravate the erosion problems.

4.5 CONSIDERATION FOR PLANNING EROSION CONTROL

Within the survey area, the major portion of the watershed that requires erosion control is the denuded forest. In cultivated and over-grazed areas, accelerated soil erosion is occuring largely because of a lack of permanent vegetation to stabilize the soil.

Several factors should be accounted for in planning improvement structures and revegetation, such as: socio-economic factors, land tenure, manpower requirements and transportation.

4.5.1 Socio-economic factors

Sufficient manpower, consisting of unskilled labourers from nearby villages would be available to construct minor improvement structures such as gully plugs or small check dams. Employment in this form would provide additional cash flow that would not otherwise be available apart from road construction work.

Considering that the area requiring improvement is being used for, cultivation, reforestation and permanent revegetation must be clearly emphasised to reduce soil erosion.

Erosion control projects definitely increase land values; therefore, encouragement must follow that the local population participate in various phases.

4.5.2 Land tenure

Past legislation has favored nationalizing all forests; however, the question of land tenure within the old burn (denuded area) and adjacent forested areas is still a major issue. Illegal cutting for structural timber and over-grazing in the commercial forest have been the cause of erosion. To carry out effective erosion control plans, ownership must be determined and cooperation from villagers secured.

4.5.3 Transportation

Until the road leading form Chawky to the Diwagal forest is completed, it will be difficult to plan and implement major improvement works and to conduct additional studies and for necessary data collection. The problem of transporting men and equipment remains.

4.5.4 Training

Apart from survey methods, no training has been undertaken in the field to teach Afghan personnel planning, lay-out, and supervision of routine operations in soil conservation. Training and supervision should be initiated by project personnel with assistance from government counterparts.

4.6 IMPROVEMENT METHODOLOGY

4.6.1 Improvement and stabilizing structures

Gully erosion, in most cases, is still moderately shallow in the denuded forest stratum. Considering the average depth of 0.9 m and average length of 27 m, a series of water retaining structures would reduce the erosive force of water.

Once the gully channel is established, the resulting concentration of flow is sufficient to sustain and enhance gully erosion. Subsequent headward erosion and widening will continue unless the gully is stabilized.

A series of small check dams using graded rock and constructed of dry masonry would be an effective measure to reduce water velocity. Cribbing, using logs and brush, would stabilize small gullies as effectively if the slope length is not too great. These structures however, generally require more maintenance than graded rock check dams.

On the few sites that feature severe gully erosion, check dams constructed with gabions would provide better results. These structures are built using galvanized wire mesh and graded rocks.

The purpose of retaining structures and check dams in addition to reducing water velocity, is to allow siltation of gully bottoms and eventual revegetation to be implemented. The FAO "Conservation Guide" series clearly outline methods to follow when constructing check dams.

4.6.2 Revegetation and reforestation

The primary aspect to consider when planning erosion control is the use of vegetation to prevent rain splash on the soil surface and the reduction of runoff velocities.

Tree seedlings planted on suitable sites provide the best long-term protection against erosion and soil degradation; however, shrubs, legumes and grasses are also a valuable source for erosion control. On selected sites that are not too badly eroded, hardy, containerized seedlings of *Cedrus deodara* and *Pinus wallichiana* could be planted.

Severely degraded sites featuring sheet erosion in some areas of the Diwagal watershed would require sowing a mixture of grasses and legumes. Alpay (1974) reports good germination rates using *Agropyron cristatum*, *Medicago sativa* and *Sanguisorba minor* in the Chapadara watershed. The amount of seed used was 25 kg/ha. Seed mixture was composed of 50 percent Agropyron, 25 percent Medicago and 25 percent Sanguisorba. When sowing separately, it is recommended that legumes be seeded in early Spring and grasses in the Fall. Row seeding was more successful than broadcast seeding.

To stabilize rill and gully erosion, trials using Indigofera gerardiana could be tried. This genus grows well throughout the denuded stratum and would be an excellent pioneer species. Alpay (1974) notes that Indigofera is a persistent shrub, sprouts very quickly and vigorously. Although it is a leguminous plant, it is not very palatable for animals. On steep sites, wattling and fascines would further stabilize cuttings and seedlings planted.

Terracing when required should include proper channel ways or waterways constructed to divert excess runoff. Terrace construction applicable to Afghanistan including improvement structures have been well illustrated by Bostanoglu (1973).

Chapter 5

MANAGEMENT ALTERNATIVES

5.1 GENERAL

Management objectives in the Kunar Valley are to provide a long range, overall cutting plan for harvesting all merchantable timber on a sustain yield basis. Essentially, objectives are to remove stagnant and overmature timber to permit a regular age class distribution over a set rotation period, and to reforest areas denuded by fire and illegal clearing.

5.2 REGULATION

Considering the portion of the Kunar Valley surveyed, the Diwagal forest comprises forest types that are overmature. Necessary management must include how much timber should be harvested in order to attain a fully regulated forest which would provide a sustain yield of timber over a desired time period. There should be a progression of size and age classes so that merchantable trees, in approximately equal volume, are available for harvesting.

5.3 EVEN-AGED MANAGEMENT

5.3.1 Allowable cut calculations

To achieve even-aged management; that is, converting stands to well defined groups in specified age classes within a management unit, various formulae can be used to compute annual allowable cuts, accounting for total gross volumes, average net growth, and rotation period.

5.3.1.1 Rotation period

The rotation period adapted for use in this plan, considering trees of various species and growth characteristics in the Diwagal forest, is 80 years. During a growth period of 80 years, sufficient tree sizes of pole and saw timber will be available to sustain a flow of products over time.

1.2.3 Climate

The climate varies considerably with altitude. Between 1 500-2 000 m of altitude, the yearly average temperature is 13 degrees Cecius and has an average yearly rainfall of 615 mm. At 2 500-3 300 m, the average temperature ranges from 2 to 8 degrees Celcius with an average yearly rainfall of 900-1 000 mm. Summers are warm and influenced by monsoon conditions from the east. Winters are long with an extensive snow cover lasting approximately 5 months at the higher elevation.

1.2.4 Soils

Forest brown soils are found throughout the coniferous areas. They have a well decomposed humus layer overlaying a sandy-clay texture. In areas of extreme relief or sites exposed to accelerated erosion, soils tend to be shallow, soil profiles poorly defined and in many cases, bedrock exposed.

1.3 DESCRIPTION OF THE DIWAGAL FOREST STAND

1.3.1 Composition

In the commercial stratum, cedar stands are found from approximately 2 000 to 2 500 m in elevation. From 2 500 to 3 300 m, an association of spruce and fir is seen with pine included from 2 800 to 3 300 m.

1.3.2 Condition

The Diwagal forest is largely overmature and stagnant. In the eastern portion, there has been intensive damage caused by burning and girdling of tree boles by the local residents. Shifting cultivation is encroaching upon the commercial stratum.

A large portion of the forest (2 497 ha) is inoperable due to unstable soil conditions (steepness); or comprised of species that cannot be used for industrial purposes and, therefore, should be left as a watershed protection area.

A fire occured approximately 15 to 20 years ago in the watershed and as a result, 677 ha of the old burn are being used by villagers to grow wheat on a shifting basis. There are residual patches of cedar which could be extracted from the area; however, villagers are rapidly killing these surviving trees to increase their cultivation area.

5.3.1.2 Von Mantel's formula

A flexible formula to compute cuts for even-aged management in overmature forests is Von Mantel's formula. It has an advantage of not requiring growth estimates of various forest types.

This formula is as follows:

$$AC = \frac{2VM}{R}$$

where: AC = Annual allowable cut

VM = Total gross volume of all merchantable trees 12.5 cm dbh and larger in the commercial and denuded strata.

R = Rotation period (80 years)

$$AC = \frac{2(752\ 834.9\ m^3)}{80}$$

$$AC = 18\ 820.9\ m^3/\text{year (gross volume)}$$

Therefore, if the entire management unit were to be converted to a regulated unit over the adjustment period, the annual allowable cut would be 18 821 m^3. Regulation of the unit, due to its overmature timber, would require less than the 80-year rotation, probably closer to 40 years. This would result in 40 age class distributions over the management unit.

The estimated annual allowable cut when using the Von Mantel's formula, in most cases, gives larger volumes than other formulae.

5.3.1.3 Hanzlik formula

The use of the Hanzlik formula requires that various areas within the management unit be stratified according to volume and maturity. The proper sequence should follow that all overmature areas be segregated and cut first while progressing to stands that are younger.

In the Diwagal forest, the entire commercial stratum is overmature; therefore, division of the forest into relatively equal areas according to maturity will not be required.

In developing a regulated, even-aged forest, the desired progression of size and age classes can be followed by an area control method when a specified number of hectares are cut every year to assure a satisfactory supply of timber for the planned operation.

The Hanzlik formula is as follows:

$$AC = \frac{VM}{R} + I$$

where: AC = Annual allowable cut

VM = Total gross volume of all merchantable trees 12.5 cm dbh and larger in the commercial and denuded forest strata.

R = Rotation period (80 years)

I = Average increment that is predicted will occur between time of computation and the time that regulation can be achieved.

Projected net growth	.703 m^3/ha/year
Estimated net growth under released conditions	4.000 m^3/ha/year
Average net growth for the rotation period is................	$\frac{4.703}{2}$ = 2.352 m^3/ha/yr

The forest area including the commercial and denuded strata is 2 620 ha, therefore:

$$2.352 \times 2\ 620 = 6\ 162\ m^3/year$$

$$AC = \frac{752\ 834.9\ m^3 + 6\ 162\ m^3}{80}$$

$$AC = 15\ 572.4\ m^3/year \text{ (gross volume)}$$

By using the Hanzlik formula, the annual allowable cut is 15 572 m^3.

5.3.1.4 Choice of annual allowable cut formula

Correlating the available gross volume with the expected future growth under released conditions over the adjustment period will permit realistic annual cuts. The Hanzlik formula quotes an annual allowable cut of 15 572 m^3.

The Von Mantel's formula computes an annual allowable cut of 18 821 m^3. Considering that portions of the forest is damaged and the overmature and stagnant nature of the forest types, annual allowable cuts could be as high as 18 821 m^3 per year. In this case, regulation over the entire management unit would be achieved sooner. This would involve a distribution of approximately 40 even-aged classes.

Necessarily, annual cuts must also be correlated with the capacity of the equipment as well as mill utilization potential. Realizing that logging operations of a magnitude requiring cable cranes and skyline yarding systems have not been used in the Kunar Valley before, an annual cut of approximately 18 821 m^3 per year may not be realistic and, therefore, the regulation period may have to be lengthen considerably.

A careful analysis relating the capacity of the equipment and realistic annual cuts should be considered.

5.3.2 Logging methods

Merchantability for all coniferous forest species has been set at a range of 12.5–27.4 cm dbh (15–25 cm dbh classes) for pole material and 27.5 cm dbh (30-cm dbh class) plus for sawtimber. Harvest cutting could be approached in two manners, a selective cut utilizing commercial timber of a desired size, or by using all merchantable trees in alternate strips.

5.3.2.1 Alternate strip method

Considering the need for pole material in Afghanistan, a proposal that would remove all merchantable trees of commercial species 12.5 cm dbh and larger in limited size strips of approximately 6 hectares should be considered. These strips could be logged entirely in an alternate pattern, thereby creating residuals which would provide seed source for natural regeneration.

All forest types are overmature in the Diwagal forest, therefore, area delineation would not be required.

This method can be easily organized and the equipment needed for logging is more flexible. Regulation of cut is by area. The various highlead and skyline yarding devices used for logging in strips would operate more efficiently and economically from single cuttings.

The following groundrules would apply:

(a) Cut strips should be oriented perpendicular to slope contours and not exceed 60 meters in width and 1000 meters in length (6 ha). In rugged terrain, it may be best to have the lengths of the strips at right angles to the contour lines for proper seed dispersal by wind. When orienting the cut strips, aspect of slopes should be considered.

(b) Cut strips should not be located beyond 100 meters of ridge tops mainly for erosion protection and to provide a seed source on ridge tops.

(c) No cutting should be permitted within 50 meters of streams except for a 10 meters lane for the skyline cable to operate.

(d) Logs once felled should not remain on a cold deck longer than 60 days because of deterioration and subsequent loss of quality.

5.3.3 Regeneration of cut strips

The correlation between the size of cut strips and the success of natural regeneration from adjacent residuals may be rather low because it affects only the dispersal of seeds. Equally important factors to consider are seed production potential of the residual, competing vegetation, slash disposal, and micro-climate on the cut strips.

Natural regeneration should restock portions of the cut strips. Sufficient seed source should be available from the residual to permit adequate regeneration in certain areas; however, it may be advisable to seed directly following proper site preparation to ensure good results.

Following a regeneration establishment period of 4 to 5 years, also the cut strips that are not deemed satisfactorily regenerated will require artificial regeneration by planting bare-rooted or containerized seedlings.

Usually, the leave strip, or residual, is logged not later than one fifth of the rotation period. If logging can coincide with a good seed year when removing the residual strip, sufficient seed source from slash distribution may regenerate the site naturally. If not, planting or direct seeding must be done after site preparation.

5.3.3.1 <u>Site preparation</u>

Site preparation in terms of reducing the amount of slash and litter to expose the mineral soil will be necessary to encourage natural regeneration.

Where feasible, tractors using brush rakes could pile brush and reduce the litter cover, although lopping and piling of brush and debris followed by prescribed burning will be as effective and probably less harmful to the site.

Where there is a large amount of litter and debris, broadcast burning will be required to expose the mineral soil. Aspect of slopes in such cases should be considered because some species require shade to regenerate.

5.4 UNEVEN-AGED MANAGEMENT

5.4.1 <u>Selection method</u>

The selection method involves removing mature timber individually or in small groups at relatively short intervals usually creating uneven-aged stands. The essential requirements is that there be at least three intermediate cuttings during the equivalent of one rotation. A normal distribution of age classes from the youngest to those of rotation age are represented in the stand.

Trees to be removed are pre-selected according to size desired and maturity. If patches or groups are too large, the system may approach a shelterwood method. In stands comprised of large, even-aged groups, the eventual constituent if not rigidly controlled may be scarcely distinguishable from a clear cut leaving the usual immature trees and weed species.

The constraint on selective cutting is that it requires more supervisory attention and skill than the previously described even-aged management. The problem exists that while felling and extraction, damage to the residual may occur.

Using the selection method, the advantages are that the existing ecological conditions are not modified to any great extent if the size of the patches removed are small. Regeneration can be easily achieved if competing vegetation is not excessive. If logged properly, this method presents the least amount of erosion loss.

5.4.2 Allowable cut calculations

The Austrian formula is perhaps the most widely used formula for computing allowable cuts for uneven-aged management. The allowable cut, as computed for a forest during the period of developing a fully regulated stand, is as follows:

$$AC = I + \frac{Vo - Vn}{n}$$

where: AC = Allowable annual cut

I = Average annual increment during period of developing desirable levels of growing stock

Vo = Volume in year "o", namely the year from which the computed allowable cut originates

Vn = Desired volume at the end of "n" year

n = The number of years accepted as a desirable period in which to develop the "target" level of growing stock.

To compute the desired volume at the end of 50 years, or the time required for developing the desired regulated forest; involves the following predictions:

1. Expected number of trees will be 150 per ha, with an average diameter of .40 m per tree and an average gross volume of 1.002 m^3.

2. The average basal area per tree will be .126 m^2, or 18.9 m^2 per ha.

3. The average volume per ha will be 150.3 m^3.

4. Expected gross volume in the commercial forest stratum will be:

$$(150.3 \times 1943)\ 292\ 033\ m^3$$

$$AC = 2.352\ m^3/ha + \frac{366.30\ m^3/ha - 150.3\ m^3/ha}{50}$$

$$AC = 2.352\ m^3/ha + 4.320\ m^3/ha$$

$$AC = \underline{\underline{6.672\ m^3/ha}}$$

Therefore, the total annual allowable cut from the commercial forest will be ($6.672\ m^3/ha \times 1943\ ha$) $12,964\ m^3$.

5.5 LOGGING EQUIPMENT REQUIRED

Considering the varying topography, size of trees, and stand density in the Diwagal forest, a careful selection of the proper logging methods and equipment required will be a key element in a successful logging operation.

A major factor to account for is that the Diwagal forest is to serve as a demonstration area. In effect, there has been no previous training using sophisticated log extraction methods.

The choice and type of logging equipment is beyond the scope of this general plan of operations. The following suggestions may serve as a base; however, modifications may be desired.

5.5.1 Highlead cable yarding system

A mobile highlead cable crane or yarder would be required for most areas within the commercial forest stratum. Vertical lift capabilities is generally restricted to clearing minor obstacles, therefore, ground disturbance is more pronounced. This system requires a greater network of roads and landings to operate efficiently because yarding is limited by the line length which varies from 200 m to 280 m. Considering that logs are not lifted but, dragged, this system generally is not efficient in a selective cutting method.

5.5.2 Skyline yarding system

A skyline yarding system would be ideal in many areas of the Diwagal commercial forest because it lifts the log without causing any soil disturbance. Properly planned, fewer roads are required in such an operation; however, expertise in setting up an efficient operation is needed. In comparison, a highlead system with conventional yarders are more efficient logging uphill while a skyline system is best for downhill logging.

5.5.3 Tractors

Crawlor tractors could operate in some areas of the commercial forest where slope does not exceed 45-50 percent. The disadvantage is that they create a fair amount of site disturbance and a properly planned network of skid roads are needed.

Where they can operate with the minimum amount of site disturbance, they are useful in skidding logs to a landing as well, can be fitted to load logs and used for site preparation.

5.6 SAWMILL

Following extraction of the felled logs to a landing deck, the option remains to load the logs on a truck and transport them to a mill site, or utilize a mobile sawmill.

Considering that the Diwagal forest road will not be constructed nor up-graded for the next few years and the necessity of utilizing the residual in the denuded stratum remains; log transport to an established mill site outside of the Diwagal forest, will not be possible.

The optimum solution would be to utilize several portable sawmills which could be easily dismantled and relocated to adjacent log decks. This would ensure that all logs felled could yield dimension lumber without the high cost of transporting logs to a fixed mill site.

Facilities for air-drying the lumber could be constructed near the landing decks and, following proper seasoning, transported to market after completion and up-grading of the forestry road.

5.7 ACCESS ROADS

A forestry road which is presently under construction will link the Korangal Pass in the Diwagal forest with Chawki village, a distance of 33 km. To date, 20 km have been completed. It should be mentioned that the portion of the road now existing will have to be modified to accomodate logging and heavy-duty equipment.

The forestry road will be six meters wide. The maximum gradient permitted is 11 percent with an average of 6 percent. Secondary and feeder roads required will be approximately 35-40 km. Secondary roads to log residual patches in the denuded forest stratum will be constructed first and this will be followed by a network of roads in the eastern portion of the commercial forest.

5.8 PROTECTION

A key element to ensure a future for the forest industry in Afghanistan and especially in the Diwagal forest, is implementing and enforcing existing laws concerning damage to forest residuals and illegal fellings. Damage to tree boles that will eventually cause mortality and illegal fellings must be prevented.

Once the cut strips and the denuded area are regenerated, protection from grazing will be required. Presently this is one of the major reasons why little regeneration is evident.

During the early summer months following the first few years after logging, active fire patrols must be encouraged to ensure that fires do not start in slash on the cut strips and spread to residuals. A fire control plan along with equipment and training will be required. With an adequate road system, frequent patrols and look-out towers will function well.

Erosion checks will be required to locate sites where improvement works might be required. Active soil erosion must be halted before it becomes too difficult to rehabilitate the site.

5.9 THINNING

Thinning in the cut strips may be desired after a period of regeneration establishment. Advanced stock removed could be used for posts or for fuel wood. This can be done if required, using the basal area approach to determine a proper level of stocking per hectare.

5.10 TAUNGYA SILVICULTURAL METHOD

Following harvesting of the commercial forest, a choice must be made as to the method of reforestation and the amount of land that will be allotted to the people presently living in scattered areas of the Diwagal forest. Consideration should include the amount of land that can be used for agricultural purposes and the area needed to sustain a commercial forest.

Presently, only the denuded forest stratum is being used for shifting cultivation, but this practice is gradually spreading to commercially productive areas. The lack of land tenure is presently responsible for poor land management. The optimum solution would require a procedure whereby the local population could continue to grow agricultural crops to meet their needs as well as a program to reforest the denuded stratum and cut-over strips in the commercial forest.

The taungya silvicultural method combines agriculture and forestry in a system whereby tree species are grown and cultured in association with agricultural crops. Site preparation, weeding, and other cultural operations are performed by the villagers with the eventual objective of having adequately stocked stands of timber.

The system would work well in areas of the Diwagal forest that are not too steep and where the local population would be encouraged to care for the seedlings while cultivating their crops. In most cases, the agriculture rotation would be 3 to 4 years in one area. This would give the seedlings time to become well established and a new area could be planted in the same fashion.

1.4 FOREST INVENTORY

1.4.1 Inventory method

The inventory was conducted during the summer of 1978. A total of 512 circular, fixed-radius sampling units, each 0.1 hectare in area, were taken along 102 km of sampling unit lines. The sampling units were spaced 200 m apart along the sampling lines and the lines 500 m apart throughout 5 244 hectares of the Diwagal watershed. Inventory methods outlined in the Inventory Handbook (McCarty, 1979) prepared for the project were closely followed. The glossary of forest inventory terms and the list of abbreviations in the handbook should be referred to when using this plan.

1.4.2 Inventory data

Summary tables of statistics, compiled from the inventory, are included in the main body of this plan. These tables give a condensation of inventory data and will provide the user of the plan a picture of the Diwagal forest and of its timber resource.

In addition, Appendix 1 includes tables of inventory data in more detailed form that will give a complete summary of the inventory compilation and interpretation.

1.5 RECOMMENDATIONS

1.5.1 Interpreting forest inventory data

Growth measured in a badly suppressed understory does not reflect potential growth following removal of the overstory. In annual allowable cut calculations, an average should be taken based on actual growth measured and estimated second growth accretion.

Localized growth studies should be made in understories which feature above average vigor that would reflect growth rates under released conditions.

5.11 REFORESTATION OF THE DENUDED AREA

5.11.1 General

A large denuded area lies within the Diwagal forest, covering 677 ha, resulting from a forest fire about 20 years ago. Presently, this area is being used for dryland shifting cultivation and as a consequence, natural regeneration has not been established with soil erosion on some sites occuring.

To prevent further soil erosion and eventually bring this into industrial wood production, a large scale reforestation plan will be required involving trials of direct seeding and planting utilizing various species.

From the erosion survey data collected in the denuded area, average slope varies from 45 to 50 percent and features many east-west exposures. The altitude varies from 2 000 to 2 400 m with an average rainfall of 500 to 700 mm per year.

5.11.2 Nurseries

5.11.2.1 Amrey Tangey Nursery

A temporary nursery was built in 1977 at Amrey Tangey in the Diwagal forest to provide seedlings for reforesting the denuded area. The nursery in the summer of 1978 was expanded to make it a permanent nursery which could also supply seedlings to regenerate cut strips in the commercial forest. It is located at 2 300 m and has approximately 300 m^2 of seed beds capable of producing 100,000 seedlings.

Presently, the only seedlings available are Cedrus deodara. After one year in the seed bed, they are transplanted into plastic bags and cared for until planted in the field.

5.11.2.2 Proposed Lam Kande Nursery

A site similar to that of Amrey Tangey should be located to provide temporary nursery facilities at Lam Kande. This would provide seedlings to reforest the western portion of the denuded area. This nursery would function until most areas in the western part are satisfactorily stocked.

5.11.3 Planting

To reforest the denuded area, hardy (1+1) containerized seedlings will be required. Bare-root (2+0) stock can be tried on less degraded sites and on areas where transportation from the nursery is not critical. Planting should be done in the late spring after the last killing frost to utilize available soil moisture.

5.11.4 Direct seeding

There are individual trees of coniferous species, mostly Cedrus deodara that will not be logged because of the high cost of extraction. These trees would be able to provide an adequate seed source to regenerate many areas that are not badly degraded. In addition, broadcast seeding using seed of Cedrus deodara and Pinus wallichiana could be done where there are few seed trees. An important factor to consider is that many sites feature advanced erosion and require site improvement before any attempts should be made to use direct seeding; especially with tree species. The areas to be regenerated must be protected from grazing if these trials are to be successful.

5.11.5 Seed collection

A continuous supply of viable seeds should be available every year for broadcast seeding purposes or for nursery seed bed expansion. Cones should be collected from every indigenous species in the commercial forest, from vigorous, dominant trees. The seed source extracted should be properly labelled, stored in a cool, dry place and if necessary, treated for fungus. A viability test on a sampling basis should be done to ensure that a high rate of germination could be expected from seed collected and stored over a period of time.

5.11.6 Regeneration survey

After a proper period for regeneration establishment from either direct seeding or planting, a regeneration survey based on a sampling method should be undertaken to estimate percent stocking of the area. Where regeneration has not been successful, further site preparation and planting with the proper species will be required.

5.11.7 Protection

Successful reforestation in the denuded forest stratum will depend largely upon receiving cooperation from the local inhabitants. Grazing and shifting cultivation must be controlled and restricted only in certain areas. In this manner, seedlings may become established in sufficient numbers to expect a commercial volume of industrial wood in the future.

5.11.8 Transportation

Transportation of seedlings will remain a problem until sufficient secondary logging roads can be constructed. By utilizing nursery stock from two nurseries, transportation problems may be less crucial in terms of seedling mortality prior to planting.

Chapter 6

ORGANIZATION

6.1 GENERAL

At all levels of operation, effective implementation of various plans for timber extraction, reforestation, and protection will depend on the efficiency of organization within the government agencies. The problems concerning housing, personnel, and channeling of expertise must be examined within the existing structure.

6.2 ORGANIZATION AND ADMINISTRATION

The Eastern Zone of Afghanistan comprises three provinces that have potential for industrial wood, fuelwood, and pulp. These are the provinces of Nangarhar, Laghman, and Kunar. Considering proposed large scale forestry operations in this zone, Kunar is the most prominent of the three and should serve as the administrative center with offices at Assadabad.

To synchronize planning and management, a general director would be appointed to administer over three provinces. He would be under the jurisdiction of the Department of Forests and Range in Kabul and his area of jurisdiction referred to as Zone; hence, his functional title: Zone Forester. The Zone would be subdivided into three regions, each comprising a province. In the Kunar Region, a Regional Forester would be responsible for four forest districts within the proposed scheme of organization. These four districts are: Assadabad, Kamdesh, Petch, and Cawki, each administered by District Forester. Each forest district will have varying numbers of subdistricts and management units. Figure 2 and 3 , outline the proposed level of organization and the division of subdistricts within each district. For example, the Chawki District will have Narang, Sarkani, Khas Kunar, and Nurgal as subdistricts and the Diwagal forest as one management unit. Smaller or less active management units may be combined within a district to form a single management unit. Each unit will be controlled by a Unit Forester.

At the zone level, five directors would be appointed to assist the Zone Forester and regional foresters in planning and administration. Each of the five directors would head a department and be responsible for planning and coordinating activities within the Zone. It is essential that each director be thoroughly familiar and experienced in all aspects within his department.

In each forest district, the District Forester would be directly responsible to the Regional Forester; however, he would receive technical assistance from directors of each department. In some cases, districts may be too small or less active and could be grouped under one District Forester.

At all levels, it is crucial that every person be fully aware of the range of responsibilities assigned to him and his expected duties. Overall guidance and monitoring of operations and personnel would come from the Department of Forests and Range in Kabul through the Zone Forester. It would also be the duty of the Department to control the budget and manpower requirements for the Eastern Zone.

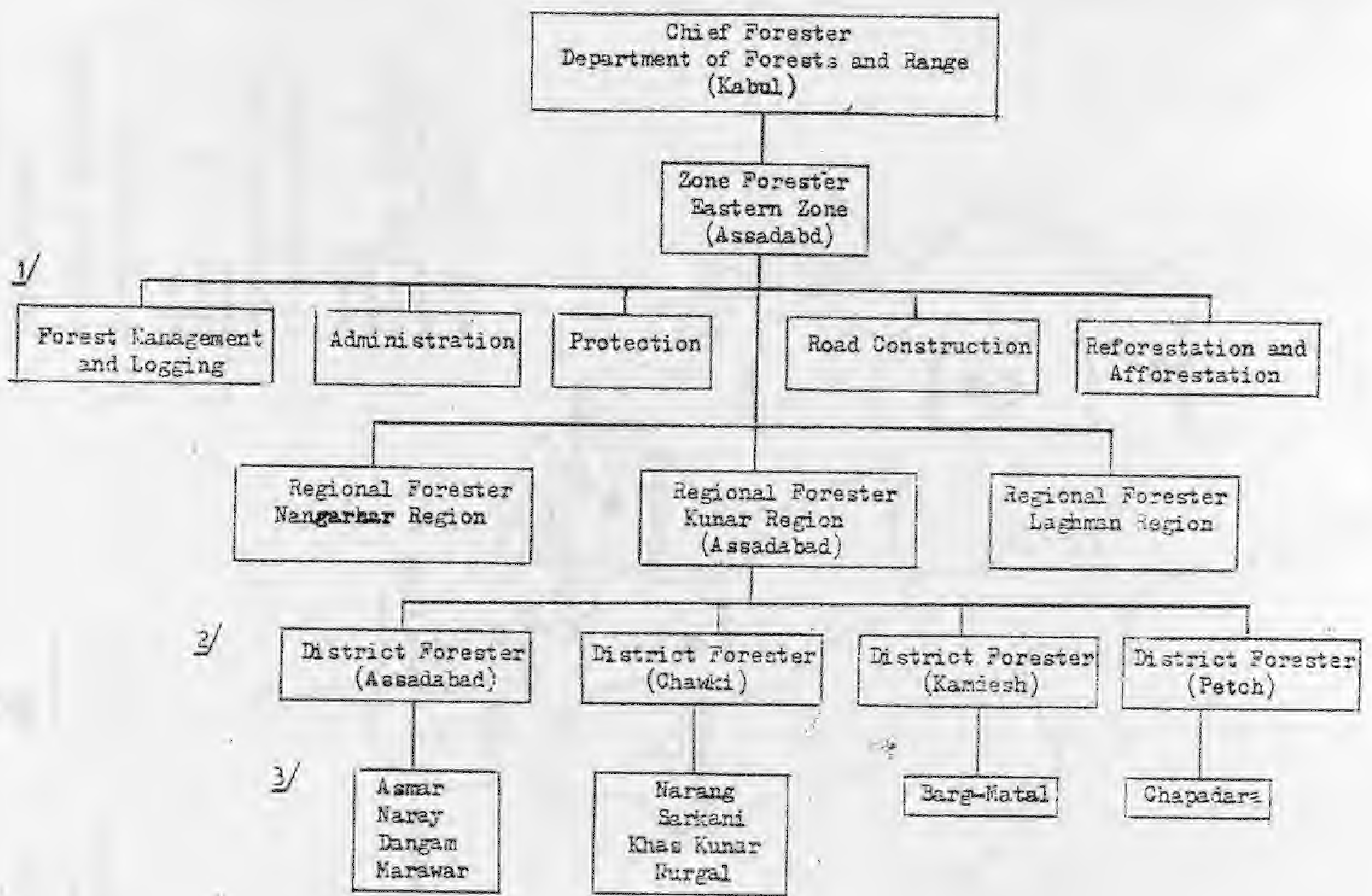
6.3 DEPARTMENTS

Five departments should be created within the organization to account for all proposed phases of forest operations. At the head of each department should be a director with extensive knowledge in his field. The departments of administration, protection, road construction, afforestation-reforestation, and forest management would be located in Assadabad. This group would plan and advise on any operation throughout the Zone. The group will be referred to as the Zone Forestry Staff.

6.4 HOUSING

To attract qualified personnel, suitable housing must be provided from forest houses to office facilities. In all cases, it is essential to have accomodation near the duty area. For example, in the eastern part of the Diwagal forest, a forest house should be constructed to lodge forest guards and technicians to prevent further illegal fellings and burning. As series of forest houses in other areas would facilitate further studies and supervision of ongoing activities.

Figure 2 ORGANIZATION CHART FOR THE KUNAR REGION



1/ Departments
2/ Forest Districts
3/ Subdistricts

Figure 3 FOREST DISTRICTS OF THE KUNAR PROVINCE



Chapter 7

RECOMMENDATIONS

7.1 FOREST MANAGEMENT

Considering the nature and condition of the Diwagal forest, the following recommendations for management are:

1. Initiate a salvage operation in the denuded forest stratum. This would involve removing scattered patches of Cedrus deodara. The total available gross volume in the denuded area is 30 000 m^3 and covers 677 hectares. Individual trees that cannot be removed will be left as seed trees to help reforest this area. However, reforestation methods as described in Section 5.11 will be the primary operation to rehabilitate the stratum.

2. Following the salvage operation in the denuded area, logging the eastern portion of the commercial forest stratum should be undertaken. This area contains many damaged trees that would eventually result in a salvage operation. The logging system that would be most practical in the commercial areais an alternate strip method whereby all merchantable timber is logged in narrow strips according to guidelines provided in Chapter 5. Following the regime of a prescribed annual allowable cut, this method will result in even-aged management.

3. A careful study of mill capacity must be correlated with annual cuts and periodically revised as expertise and efficiency increase. Initial returns from logging would help fund reforestation in the denuded area as well as major improvement and protection works along the forest road.

4. Considering the overmature condition of the Diwagal forest, annual cuts could deviate from any annual allowable cut calculations. This would result in fewer even-aged class distributions over the rotation period and initiate the start of a vigorous young forest.

5. Annex commercial areas from adjacent forests with the Diwagal forest to ensure greater flexibility in order to manage all areas under sustain yield management. This would involve the outcome of further inventories in the Kunar Valley.

6. Following reforestation of the denuded area, at a certain period during the rotation, merchantable trees will be available for logging. This will require a modification of the annual allowable cut calculations and volume estimates within the Diwagal forest.

7.2 RECOMMENDATION FOR FUTURE INVENTORIES

Adjacent forests of the Chapadara and Korangal watersheds should be inventoried at the same intensity of sampling as the Diwagal forest. Delineation of commercial and non-commercial strata should follow the same format as that used in the Diwagal inventory.

Further inventories later in the future could be done in the Diwagal forests to reassess growth and volume estimates.

Once the denuded area has been reforested and appears to have sufficient merchantable volume to include in the management unit, an inventory will be required to determine volume and related site data.

7.3 EROSION CONTROL

1. Planting of seedlings of either Pine or Cedar should be done at one meter spacing near gully heads and rims. On less eroded sites, planting can be at intervals of two meters. An early crown closure and heavy litter build-up is the objective. On steep, degraded sites, trials using cuttings of Indigofera sp. and sowing of grasses and legumes should be considered. Monospecific vegetation composition is not necessarily the most effective means to control erosion. Several species of tree seedlings as well as shrubs should be considered.

2. Illegal fellings in the commercial forest now occuring to increase land for cultivation purposes must be prevented to reduce further erosion losses.

3. Meteorological data, runoff, and sediment monitors in various catchments are needed for more intensive watershed management. Included would be snowcourse measurements at various altitudes within the watershed.

7.4 REFORESTATION

1. A temporary nursery at Lam Kande should be considered to provide seedlings to reforest the western part of the denuded area. Included in the reforestation plan would be seedlings from the Amrey Tangey nursery. Seedlings used should be hardy (1+1), preferably containerized. Planting should follow only after careful site preparation.

2. Reforestation using seedlings of Cedrus deodara should be used on selected sites that are not badly degraded. Reforestation efforts would coincide with the erosion control recommendations in order to prevent further soil loss and make the denuded area productive for future wood utilization.

3. The Taungya silvicultural system as described in Section 5.10 should be considered when implementing reforestation. Properly applied, this system would be of mutual benefit to both government authorities and many villagers presently living in the Diwagal forest.

1.5.2 Initial logging operations

Salvage operations in the old burn area will be limited to residual patches of Cedar. These patches are scattered throughout the burn and should be logged before further deterioration and loss occurs.

The eastern portion of the commercial forest stratum has been extensively damaged by burning and girdling of tree boles. In the future, this area will require a salvage operation which should be initiated after operations in the burn are completed.

1.5.3 Government regulation

Enforcement by government authorities will be required to ensure that further damage to the forest is not done. The problem of land tenure in the denuded portion of the watershed should be solved so a reforestation plan can be implemented.

1.5.4 Annual harvest

Considering the overmature nature of the Diwagal forest the annual allowable cut could be as high as 18 821 m^3 as prescribed by the Von Mantle's formula.

1.5.5 Erosion control

Many sites feature advanced rill and gully erosion which should be stabilized and revegetated. A total of 28 ha in the denuded forest stratum are to be rehabilitated for various forms of erosion.

1.5.6 Reforestation of the denuded area

A plan should be implemented to regenerate 677 ha of the denuded forest stratum. Shiftingciltivation there must be stopped and grazing limited to certain areas. A temporary nursery at Lam Kande should be constructed to supply seedlings to reforest the western part of the denuded stratum.

Appendix 1

FOREST INVENTORY DATA

A1.1 VOLUME COMPOSITION BY SIZE CLASS

Table A1

COMMERCIAL FOREST STRATUM

SPECIES	PERCENT OF GROSS VOLUME OF TOTAL		
	POLE	SAW	ALL
Cedrus deodara	.4	58.9	59.3
Pinus wallichiana	.05	13.2	13.2
Abies spectabilis & Taxus baccata	.7	15.3	16.0
Picea smithiana	.4	11.1	11.5
TOTAL	1.5	98.5	100

Table A2

DENUDED FOREST STRATUM

SPECIES	PERCENT OF GROSS VOLUME OF TOTAL		
	POLE	SAW	ALL
Cedrus deodara	1.3	98.7	100

A1.2 TOTAL NUMBER OF TREES, BASAL AREA, AND GROSS VOLUME BY SPECIES AND STRATUM

Table A3

COMMERCIAL FOREST STRATUM

SPECIES	TOTAL TREES (number)	TOTAL BASAL AREA (m^2)	TOTAL GROSS VOLUME (m^3)
Cedrus deodara	74 447	33 489.2	428 582.6
Pinus wallichiana	23 761	7 410.1	95 753.9
Abies spectabilis & Taxus baccata	58 081	10 848.2	115 771.6
Picea smithiana	27 669	7 507.0	83 012.4
TOTAL	183 958	59 254.5	723 120.5

Table A4

DENUDED FOREST STRATUM

SPECIES	TOTAL TREES (number)	TOTAL BASAL AREA (m^2)	TOTAL GROSS VOLUME (m^3)
Cedrus deodara	6 004	2 272.4	29 714.5

Table A5

ALL FOREST STRATA
(Commercial and Denuded)

SPECIES	TOTAL TREES (number)	TOTAL BASAL AREA (m^2)	TOTAL GROSS VOLUME (m^3)
Cedrus deodara	80 451	35 761.6	458 297.1
Pinus wallichiana	23 761	7 410.1	95 753.9
Abies spectabilis & Taxus baccata	58 081	10 848.2	115 771.6
Picea smithiana	27 669	7 507.0	83 012.4
TOTAL	189 962	61 526.9	752 835.0

A1.3 GROSS VOLUME AND BASAL AREA FOR POLE AND SAWTIMBER BY SPECIES AND STRATUM

Table A6

COMMERCIAL FOREST STRATUM

	BASAL AREA/ha (m^2)		TOTAL BASAL AREA (m^2)		VOLUME (m^3)		TOTAL GROSS VOLUME (m^3)	
SPECIES	POLE	SAW	POLE	SAW	POLE	SAW	POLE	SAW
(A) CONIFERS								
Cedrus deodara	.177	17.06	343.2	33 146.0	1.401	219.18	2 722.4	425 860.2
Pinus wallichiana	.052	3.76	101.0	7 309.1	.220	49.06	427.2	95 326.7
Abies spectabilis & Taxus baccata	.316	5.27	615.7	10 232.5	2.712	56.87	5 269.5	110 502.1
Picea smithiana	.121	3.74	235.1	7 272.8	1.509	41.2	2 932.2	80 080.2
TOTAL	.666	29.83	1 295.0	57 960.4	5.842	366.32	11 351.3	711 769.2
(B) BROADLEAF								
Quercus baloot	.875	7.35	1 700.5	14 276.7	2.661	41.92	5 169.7	81 450.5

Table A7

DENUDED FOREST STRATUM

	BASAL AREA/ha (m^2)		TOTAL BASAL AREA (m^2)		VOLUME/ha (m^3)		TOTAL GROSS VOLME (m^3)	
SPECIES	POLES	SAW	POLES	SAW	POLES	SAW	POLES	SAW
(A) CONIFERS								
Cedrus deodara	.071	3.28	48.4	2 224.0	.571	43.320	386.9	29 327.5
(B) BROADLEAF								
Quercus baloot	.195	3.49	131.9	2 362.7	.584	19.07	395.5	12 910.6

A1.4 NUMBER OF TREES AND AVERAGE DBH BY SPECIES, STRATUM, AND SIZE CLASS

Table A8

COMMERCIAL FOREST STRATUM

SPECIES	POLES			SAW			ALL		
	Trees/ha	Total Trees	Ave. DBH (m)	Trees/ha	Total Trees	Ave. DBH (m)	Trees/ha	Total Trees	Ave. DBH (m)
Cedrus deodara	5.11	9 926	.200	33.21	64 521	1.110	38.32	74 447	.655
Pinus wallichiana	1.63	3 168	.200	10.60	20 593	.781	12.23	23 761	.491
Abies spectabilis & Taxus baccata	10.65	20 697	.197	19.24	37 384	.810	29.89	58 081	.504
Picea smithiana	4.02	7 815	.199	10.21	19 854	.859	14.24	27 669	.545
Total Conifers	21.41	41 606	.199	73.26	142 352	.890	94.68	183 958	.549
Total Broadleaf	25.87	50 264	.201	41.09	79 834	.842	66.96	130 100	.522

Table A9

DENUDED FOREST STRATUM

SPECIES	POLES			SAW			ALL		
	Trees/ha	Total Trees	Ave. DBH (m)	Trees/ha	Total Trees	Ave. DBH (m)	Trees/ha	Total Trees	Ave. DBH (m)
Cedrus deodara	2.67	1 811	.199	6.19	4 193	.819	8.87	6 004	.509
Total Broadleaf	4.79	3 242	.194	4.61	13 632	.630	10.19	16 874	.412

A1.5 GROSS VOLUME PER HECTARE BY SPECIES AND DBH CLASS (m^3/ha)

Table A10

COMMERCIAL FOREST STRATUM

DBH Class	Cedrus deodara	Pinus wallichiana	Abies spectabilis & Taxus baccata	Picea smithiana	All
15	.198	.019	.762	.451	1.430
20	.486	.061	.936	.566	2.049
25	.717	.140	1.015	.492	2.364
Total Poles	1.401	.220	2.713	1.509	5.843
30	.673	.418	1.226	.711	3.028
35	1.164	.308	1.008	.633	3.113
40	2.175	1.012	1.596	1.131	5.914
45	2.737	1.164	3.020	.923	7.844
50	4.233	1.931	4.393	1.172	11.729
55	4.444	3.596	3.542	2.183	13.765
60	5.550	2.441	4.836	1.332	14.159
65	5.447	2.618	3.919	1.053	13.037
70	10.129	2.888	3.609	1.704	18.330
75	11.194	4.229	3.868	3.592	22.883
80	10.766	3.407	3.395	3.549	21.117
85	12.263	2.976	2.848	3.379	21.466
90	14.718	4.038	4.614	5.683	29.053
95	15.019	4.393	1.477	2.251	23.140
1.00	12.683	3.123	2.363	1.965	20.134
1.05	6.392	3.470	2.561	1.718	14.141
1.10	8.921	2.272	1.453	1.337	13.983
1.15	11.079	.875	-	1.452	13.406
1.20	7.781	2.742	1.988	.831	10.847
1.25	15.564	-	1.113	.891	17.568
1.30	2.182	-	1.169	1.009	4.360
1.35	6.781	1.159	-	-	7.940
1.40	4.976	-	2.873	1.173	9.022
1.45	9.261	-	-	-	9.261
1.50	5.632	-	-	-	5.632
1.55	1.493	-	-	-	1.493
1.60	4.731	-	-	1.545	6.276
1.65	6.817	-	-	-	6.817
1.70	1.803	-	-	-	1.803
1.75	-	-	-	-	-
1.80	2.070	-	-	-	2.070
1.85	-	-	-	-	-
1.90	4.770	-	-	-	4.770
1.95	-	-	-	-	-
2.00	2.666	-	-	-	2.666
2.05	-	-	-	-	-
2.10	3.065	-	-	-	3.065
Total Saw	219.179	49.060	56.871	41.217	366.328
Total Saw & Pole	220.580	49.280	59.584	42.726	372.171

Table A11

DENUDED FOREST STRATUM

DBH Class	Cedrus deodara
.15	.227
.20	.247
.25	.097
Total Poles	.571
.30	.136
.35	.110
.40	.598
.45	.585
.50	.734
.55	.349
.60	1.755
.65	1.012
.70	1.295
.75	.673
.80	2.584
.85	2.943
.90	1.172
.95	2.636
1.00	1.435
1.05	1.586
1.10	5.623
1.15	5.839
1.20	-
1.25	-
1.30	5.492
1.35	2.923
1.55	3.840
Total Saw	43.320
Total Saw & Poles	43.891

A1.6 AVERAGE GROSS VOLUME PER TREE BY SPECIES AND DBH CLASS (m^3)

Table A12

COMMERCIAL FOREST STRATUM

DBH Class	Cedrus deodara	Pinus wallichiana	Abies spectabilis & Taxus baccata	Picea smithiana
15	.165	.033	.182	.296
20	.242	.124	.246	.372
25	.376	.257	.381	.503
30	.443	.481	.537	.654
35	.714	.810	.598	.893
40	1.002	1.095	1.013	1.156
45	1.362	1.529	1.323	1.416
50	1.771	2.090	1.720	1.798
55	2.339	2.646	2.173	2.232
60	2.921	3.453	2.697	2.724
65	3.342	4.015	3.797	3.230
70	4.238	4.829	3.906	3.918
75	5.159	5.962	4.746	4.720
80	6.014	6.968	5.677	5.443
85	7.047	7.832	6.546	6.222
90	8.222	9.283	7.716	6.973
95	9.214	10.099	9.062	8.277
1.00	10.569	11.483	10.890	9.053
1.05	11.771	12.760	11.802	10.542
1.10	13.682	13.936	13.326	12.265
1.15	14.559	16.211	—	13.317
1.20	15.912	16.820	18.243	15.398
1.25	17.890	—	20.611	16.502
1.30	20.017	—	21.650	18.694
1.35	20.800	21.456	26.360	—
1.40	22.931			21.713
1.45	24.371			—
1.50	25.952			—
1.55	27.643			—
1.60	29.026			28.603
1.65	31.417			
1.70	33.387			
1.75	—			
1.80	38.333			
1.85	—			
1.90	43.761			
1.95	—			
2.00	49.377			
2.05	—			
2.10	56.755			

Table A13

DENUDED FOREST STRATUM

DBH Class	Cedrus deodara (m^3)
15	.161
20	.250
25	.346
30	.483
35	.779
40	1.062
45	1.382
50	1.735
55	2.475
60	3.117
65	3.589
70	4.498
75	4.773
80	6.109
85	6.957
90	8.313
95	9.348
1.00	10.176
1.05	11.249
1.10	13.293
1.15	13.803
1.20	—
1.25	—
1.30	19.476
1.35	20.731
1.40	—
1.45	—
1.50	—
1.55	27.233

A1.7 PROJECTED NET ANNUAL GROWTH PER HECTARE BY DIAMETER CLASS FOR THE PERIOD 1979 THROUGH 1988 (m^3/ha/year)

Table A14

COMMERCIAL FOREST STRATUM

DBH Class	Cedrus deodara	Pinus wallichiana	Abies spectabilis & Taxus baccata	Picea smithiana	TOTAL
15	.021	.011	.098	.011	.141
20	.026	.010	.058	.007	.101
25	.038	.028	.044	–	.110
Poles	.085	.049	.200	.018	.352
30	.024	.003	.041	.013	.081
35	.008	.011	.031	.031	.081
40	.013	.024	.040	.023	.100
45	.016	.039	.031	–	.086
50	–	–	–	–	–
55	.003	–	–	–	.003
Saw	.064	.077	.143	.067	.351
Saw & Poles	.149	.126	.343	.085	.703

1.6 ARRANGEMENT OF THE PLAN

This forest management plan is presented in 7 chapters and 2 appendixes. Chapters 2-4 present a summary and interpretation of the forest inventory data and the erosion damage assessment; Chapter 5 discusses management alternatives; Chapter 6 offers an organization outline; and Chapter 7 presents recommendations for management of the Diwagal forests. The appendixes provide additional tables of inventory data, and reference publications.



Appendix 2

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Chapter 2

SUMMARY OF INVENTORY DATA

2.1 GENERAL

On the basis of commercial potential, operability, present and past land use, various areas of the Diwagal watershed can be stratified as follows:

Table 1
AREA STRATIFICATION

STRATUM	NUMBER OF HECTARES	PERCENT OF TOTAL
Commercial Forest	1 943	37
Denuded Forest (Shifting cultivation)	677	13
Non-commercial Forest	2 497	48
Agriculture Land (Terraced)	127	2
TOTAL:	5 244	100

Inventory data show that there are 723 120 m^3 of industrial wood in the commercial stratum and an additional 29 714 m^3 in an old burn area (denuded stratum). Total gross volume available is therefore, 752 835 m^3.

The portion of the Diwagal forest considered commercial is generally stagnant and overmature. In certain areas there has been extensive damage caused by villagers in attempting to clear land for agriculture. This damage is evident in the form of burning and girdling of tree boles. Illegal cuts of the best quality cedar trees occur largely for structural timber and fence posts.

Overall, few young stands of conifers exist. The understory, if present, is badly suppressed. There is little regeneration because of over-grazing.

Nearly half of the survey area was inoperable or comprised of species not suitable for industrial wood. Several large drainages originating in this area supply the lower valley with water; consequently, these are critical watershed protection areas.

A portion of the Diwagal watershed was denuded by a forest fire about 20 years ago. This area was never regenerated because local inhabitants are using the land on a shifting basis to grow wheat. Accelerated soil erosion in some locations is quite advanced. Residual patches of cedar sawtimber are scattered throughout the denuded area, but are suffering high mortality caused by the local inhabitants in order to increase their agricultural areas and food production.

2.1.1 Net volume

Tables 3-5, on the following page, are expressed in gross volume figures which is the total m^3 volume in the merchantable portion of the tree's bole. During the inventory, the amount of cull material within this merchantable portion was recorded. This cull is the visible defective material that would be cut from the logs before they are removed from the forest. Table 2, below, illustrates the cull material as a percent of the merchantable volume. To compute net volume, additional deductions are necessary for defective material within the logs and for the loss in breakage occuring during logging operations.

Table 2

PERCENT OF CULL IN STANDING TREES

SPECIES	CULL (%)
Cedrus deodara	12
Pinus wallichiana	6
Abies spectabilis and Taxus baccata	5
Picea smithiana	4

Because of the uncertainty of the actual percentage of soundwood that can be utilized, the entire compilation has been based on gross volume instead of estimated net volume.

2.2 SUMMARY TABLES OF INVENTORY DATA

The following tables summarize volume data; more detailed tables are presented in Appendix 1.

2.2.1 Volume per hectare and total gross volume for pole and sawtimber by species and stratum.

Table 3

COMMERCIAL FOREST STRATUM

SPECIES	VOLUME/ha (m^3)			TOTAL GROSS VOLUME (m^3)		
	Pole	Sawtimber	All	Pole	Sawtimber	All
Cedrus deodara	1.401	219.18	220.58	2 722.4	425 860.2	428 582.6
Pinus wallichiana	.220	49.06	49.28	427.2	95 326.7	95 753.9
Abies spectabilis & Taxus baccata	2.713	56.87	59.58	5 269.5	110 502.1	115 771.6
Picea smithiana	1.509	41.22	42.73	2 932.2	80 080.2	83 012.4
TOTAL	5.843	366.33	372.17	11 351.3	711 769.2	723 120.5

Table 4

DENUDED FOREST STRATUM

SPECIES	VOLUME/ha (m^3)			TOTAL GROSS VOLUME (m^3)		
	Pole	Sawtimber	All	Pole	Sawtimber	All
Cedrus deodara	.571	43.32	43.89	386.9	29 327.5	29 714.4

Table 5

ALL FOREST STRATA (COMMERCIAL AND DENUDED)

SPECIES	TOTAL GROSS VOLUME (m^3)		
	Pole	Sawtimber	All
Cedrus deodara	3 109.3	455 187.7	458 297.0
Pinus wallichiana	427.2	95 326.7	95 753.9
Abies spectabilis & Taxus baccata	5 269.5	110 502.1	115 771.6
Picea smithiana	2 932.2	80 080.2	83 012.4
TOTAL	11 738.2	741 096.7	752 834.9

2.2.2 Summary of measured growth by species

Table 6

COMMERCIAL FOREST STRATUM

SPECIES	Measured Accretion 1968–77 (m^3/ha)	Measured Ingrowth 1968–77 (m^3/ha)	Measured Mortality 1968–77 (m^2/ha)
Cedrus deodara	.107	.160	.054
Pinus wallichiana	.100	.070	.003
Abies spectabilis & Taxus baccata	.222	.580	.009
Picea smithiana	.059	.070	.009
TOTAL	.488	.880	.075

2.2.3 Summary of statistical values by strata

Table 7

COMMERCIAL AND DENUDED FOREST STRATA

Stratum		Standard Error of Mean (m^3/ha)	Sampling Error (%)
Commercial	Poles (All Species)	± .66	± 12.3
	Sawtimber (All Species)	± 20.50	± 5.7
	Combined	± 20.00	± 5.5
Denuded	Poles (Cedar)	± .21	± 37.9
	Sawtimber (Cedar)	± 11.48	± 25.2
	Combined	± 11.60	± 25.1

FO: DP/AFG/79/009
Field Document 2

FOREST MANAGEMENT PLAN FOR THE DIWAGAL FOREST

AFGHANISTAN

ASSISTANCE TO FORESTRY AND WATERSHED DEVELOPMENT

Prepared for the
Government of the Democratic Republic of
Afghanistan

by
E. Hotte, U.N. Volunteer
and Inventory Officer Counterparts

UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Kabul, 1979

FAO. Forest Management Plan for the Diwagal Forest, by
E. Hotte, et al., Kabul, 1979. 60 p., 1 map, figs, tables.
FO: DP/AFG/79/009, Field Document No.2.

ABSTRACT

The Democratic Republic of Afghanistan, assisted by the United Nations Development Programme and the Food and Agriculture Organization of the United Nations, prepared a forest management plan of the Diwagal Forest based on data collected and compiled in 1978-79.

The plan outlines practical management objectives for the Diwagal Forest and in addition provides suggestions and recommendations for future management planning in the Kunar Valley.

The forest management plan is presented in 7 chapters and 2 appendixes. Chapters 2-4 present a summary and interpretation of the inventory data and erosion damage, Chapter 5 discusses management alternatives; Chapter 6 offers an organization outline; and Chapter 7 presents recommendations for management of the Diwagal forest. The appendixes provide additional tables of inventory data and reference publications.

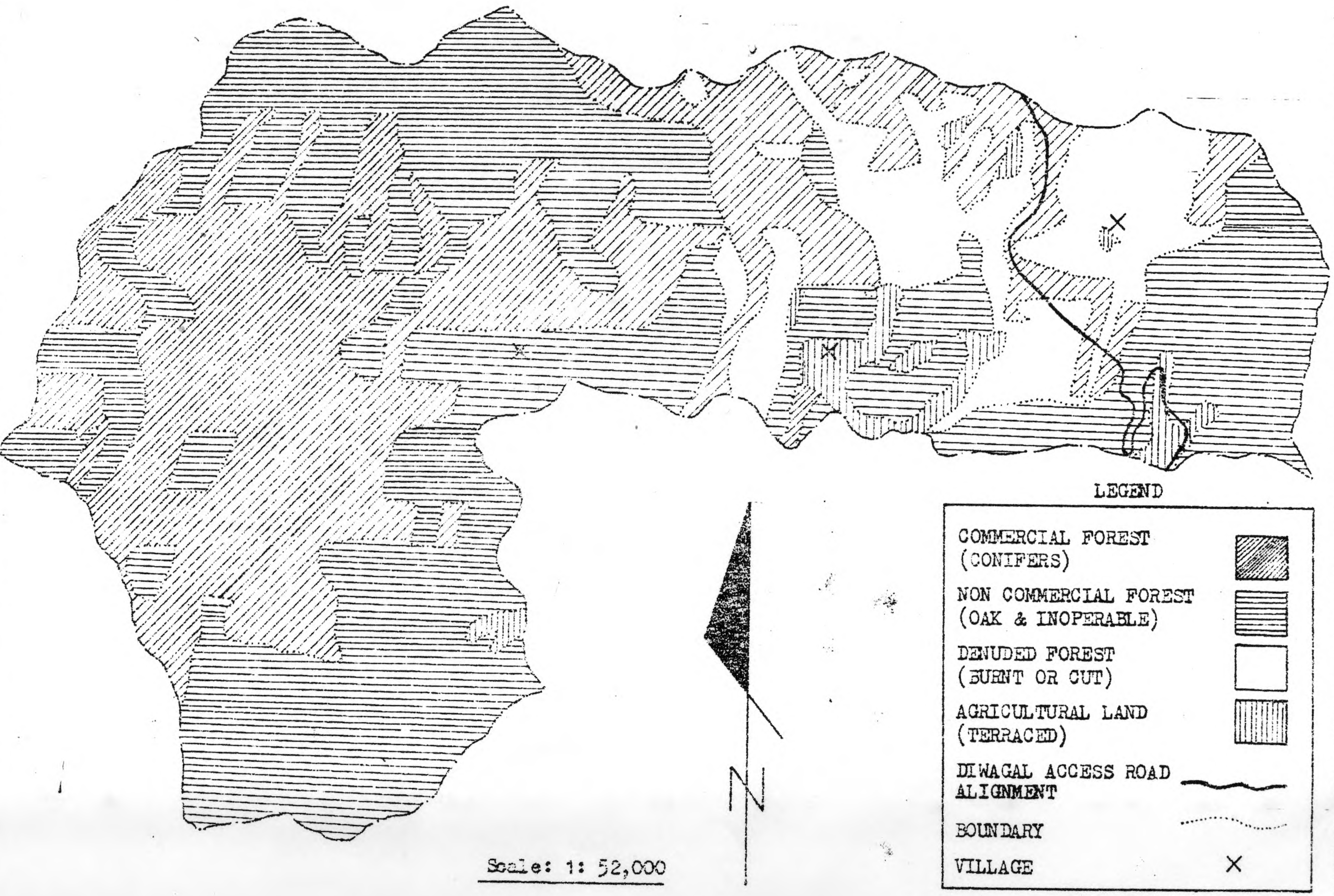
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BOUNDARY
VILLAGE
N
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